Overview of DTA Guidelines: Traffic Modeling and Calibration

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Agenda

1. Traffic modeling for DTA
2. Overview of calibration methodology

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1. Traffic modeling for DTA
   1. Flow Propagation
   2. Lane-based Effects
   3. Intersection Models
2. Overview of modeling process

Traffic Modeling for DTA

Introduction

- The traffic model is a critical component of any DTA model
  - Fidelity (realism) is a important differentiator between DTA models
  - Appropriate level of fidelity depends on modeling requirements
- Properties of traffic models can be categorized as:
  - Basic flow propagation (longitudinal dynamics)
  - Lane-based effects
  - Intersection model properties

Flow Propagation

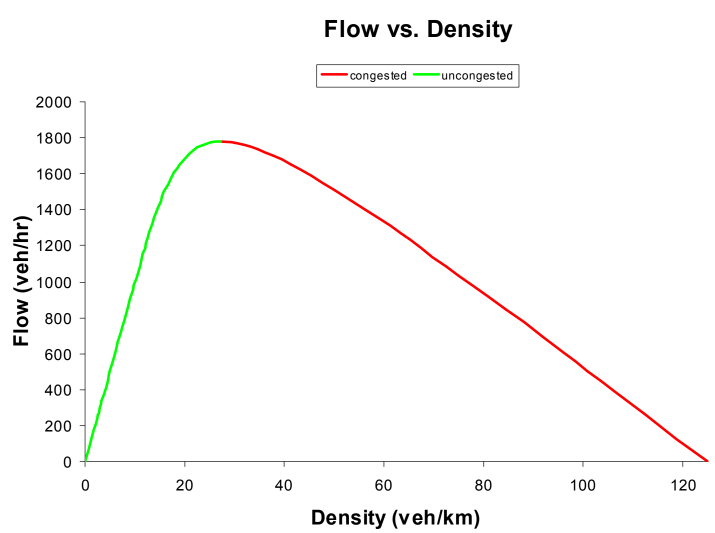
Basic flow propagation requires the following

- Respects fundamental diagram of traffic
  - “basic traffic flow principles”

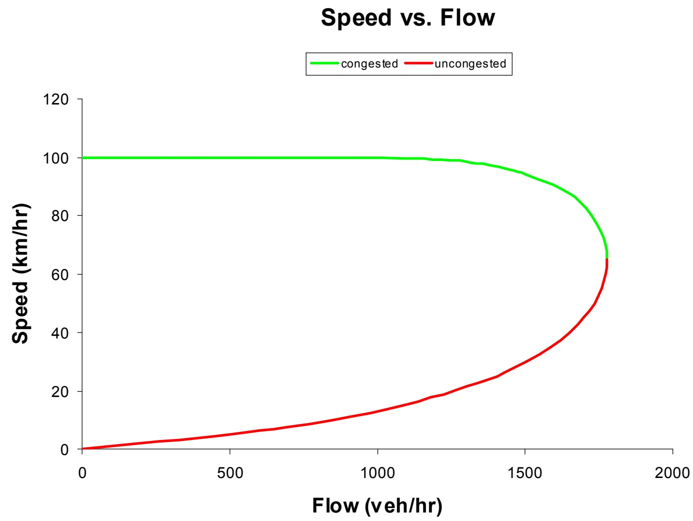
Properties

- For a given outflow (e.g. bottleneck capacity), traffic exhibits the *corresponding values* of density and speed
- When link inflow > link outflow: the volume of traffic at the outflow density (the queue) will continue to grow in the upstream direction (wave propagation)
- Eventually it will propagate across the link entrance to upstream links: “queue spillback”

Fundamental Diagram - 1



Fundamental Diagram - 2



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Lane-Based Effects

Properties of traffic on multi-lane facilities

- Non FIFO (First-In-First Out) behaviour
  - vehicles going straight through overtaking vehicles waiting to turn
- Lateral spill-over of congestion across lanes
  - over-saturation of one movement, resulting in “lateral spill-over”, chokes off capacity for other movements
- Weaving effects on freeways
  - Leads to drop in capacity
- Impact of interchange design
  - E.g. on-ramp moved from outside edge of roadway to inside edge: will impact weaving behaviour

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Intersection Models

Properties of traffic and system at intersections

- Uncontrolled conflicts (priority behaviour)
  - Freeway merges
  - Stops and roundabouts
  - Permitted (yielding) left and right-turn-on-red (signalized)
- Traffic signals
  - Basic pre-timed signals
  - Lane-based signals (e.g. transit / taxi phases)
  - Actuated and adaptive signals
  - Advanced: transit pre-emption, ramp metering

Traffic Models: Summary

- Different traffic models have different levels of fidelity
- Higher fidelity generally means:
  - More detailed representation of system (more data): higher realism and more detailed outputs
  - More sensitive: may take more iterations
- Lower fidelity generally means:
  - Less realism/detail, less detailed outputs, less inputs
  - Less sensitive: may take fewer iterations
- DTA models (that respect traffic flow principles) are considerably more realistic than static models: therefore, more sensitive (less forgiving) to errors in input data

Agenda

1. Traffic Models: Types and Properties
2. Overview of modeling process
   1. Calibration data
   2. Calibration process

Calibration Data - 1

Calibration data may consist of

- Traffic counts
  - Turning-movement counts are preferable to link-based counts
  - For freeways, ramp counts are essential in addition to mainline counts
- Queue lengths
  - At least, need to know if traffic is congested or free-flowing, for as many count locations as possible
- Travel time runs
  - Particularly important for key areas of interest

Calibration Data - 2

General remarks

- Data should be checked/validated (e.g. use statistical package to identify outliers)
- Data should be collected over several days to get averages
- Traffic data varies in a number of ways:
  - By season, by day(s) of week
- Season and days of the week should be chosen to be consistent with demand data (matrix)
- All data should be time-varying (e.g. 15-min intervals)
- Good network coverage is vital for a good calibration

Calibration - 1

Calibration = modifying input data to get desired (improved) output

- Any modification to input data should be motivated or justified as either:
  - A correction of an input/coding error
  - Replacing a default with a more realistic value
  - Compensation for a known limitation of the model
  - Adjusting data that is not known with high certainty

Any other modification is an abuse (cheating) and will degrade the predictive capability of the model

Calibration - 2

Typical calibration examples

- Default values of saturation flow may require adjustment
  - Impact of grade of road, lane width, side friction
- The traffic model does not explicitly represent a congestion mechanism that is at work in reality:
  - Capacity drop due to weaving (freeways)
  - Congestion and free-flow on neighbouring lanes
- Driver behaviour
  - Some route choices may require generalized cost
    - Penalizing turns, off-ramp / on-ramp combination
- Demand adjustment
  - May be justified/required

Calibration - 3

Typical examples of abuses

- Modifying signal timing
  - E.g. increasing capacity when in fact the problem is that the demand is too high
- Adding an extra lane
  - i.e. increasing capacity when in fact the problem is that the model is not handling multi-lane effects properly
- Modifying demand, when in fact:
  - The model is not handling routing properly, or;
  - A coding error is affecting path desirability

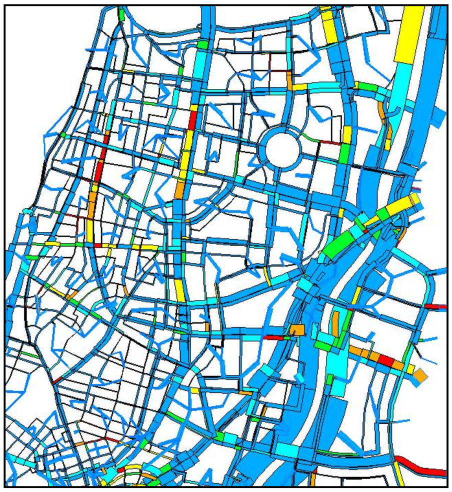
Calibration - 4

Calibration can be broken down into two stages

- **(1) Qualitative**: No point commencing a detailed analysis before certain conditions are satisfied by the DTA results:
  - Convergence (approx. equilibrium conditions)
  - No deadlocks,
  - General acceptance of bottleneck locations
- This phase of calibration characterized by **unstable behaviour** of the model
  - *small changes* to inputs can result in *large changes* to the outputs, e.g. link flows and travel times
  - This is due to excessive congestion, which often occurs due to network coding or other data errors

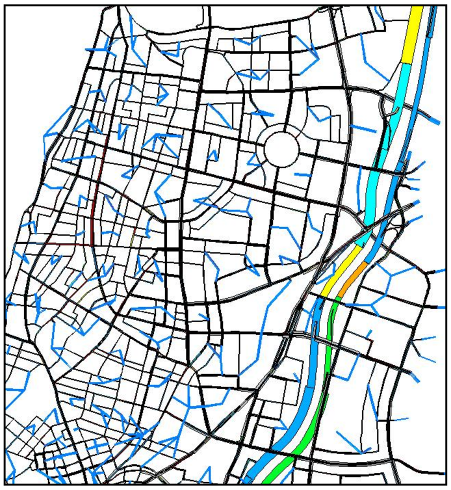
Example: unstable conditions (1 of 4)

Network at 8:00



bar width = flow

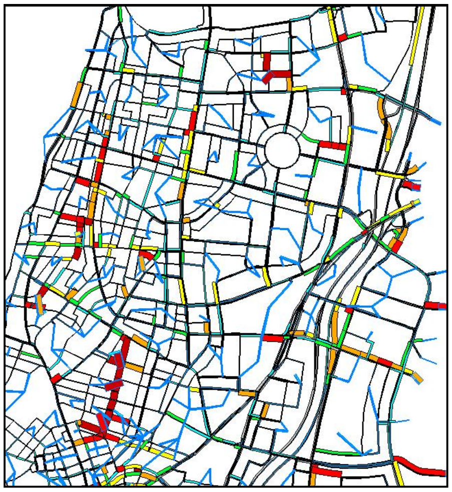
Network at 9:00



bar width = flow

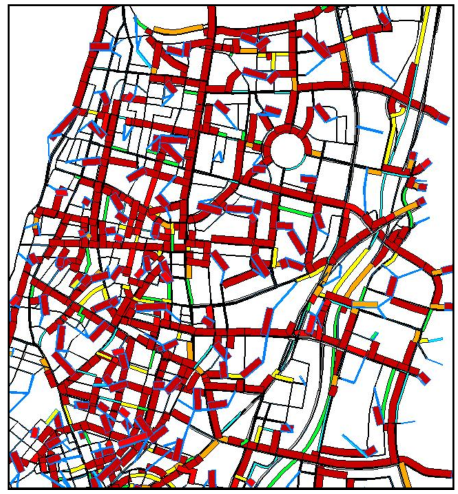
Example: unstable conditions (2 of 4)

Network at 8:00



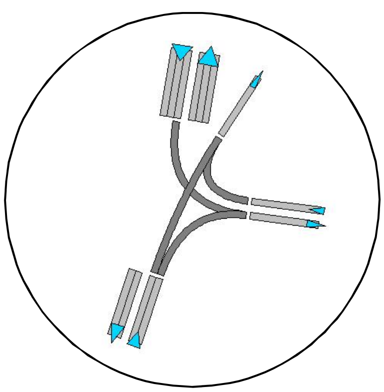
bar width = density

Network at 9:00



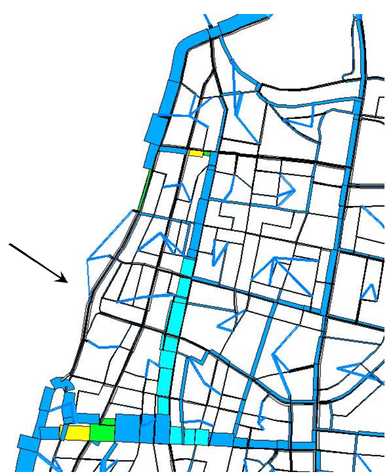
bar width = density

Example: unstable conditions (3 of 4)

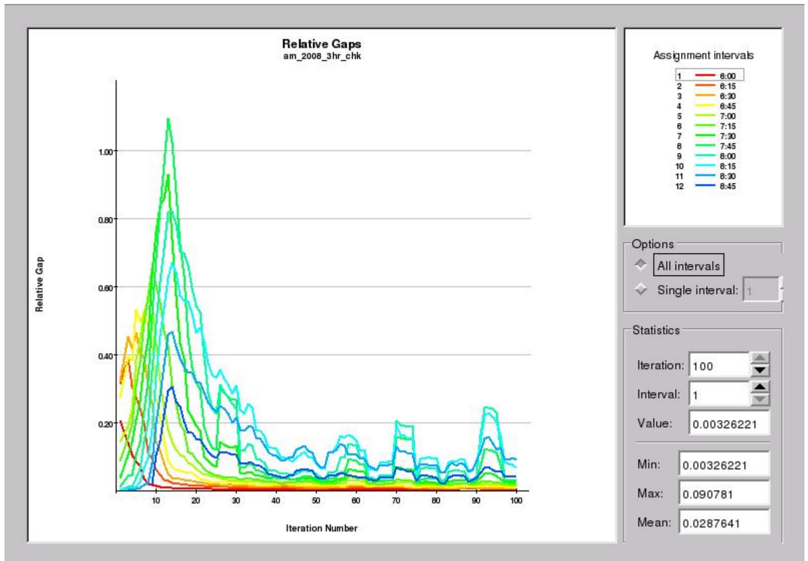


Due to coding error road is blocked, resulting in re-routing and excessive congestion

Select like analysis at 8:00 am



Example: unstable conditions (4 of 4)



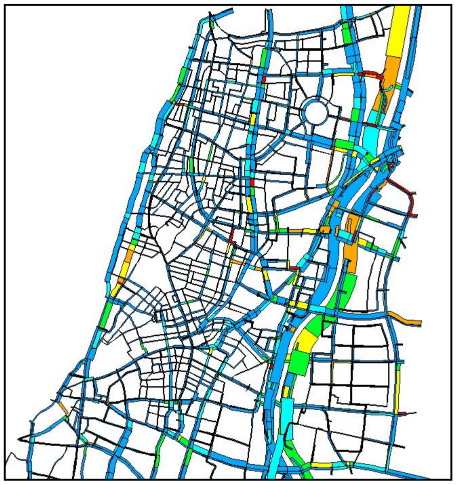
Calibration - 5

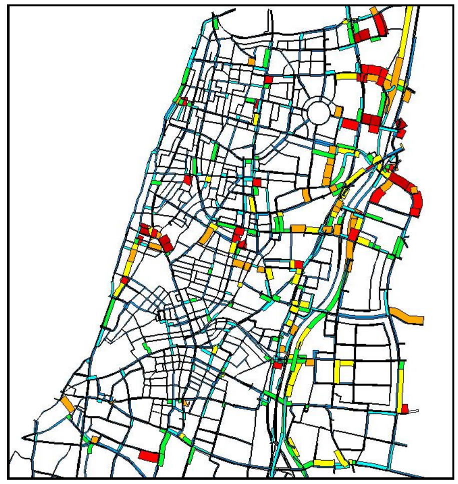
(two stages of calibration …cont'd)

- **(2) Quantitative**: model refinement, based on detailed comparison of model outputs to empirical data:
  - First calibrate capacities to traffic counts
  - Then evaluate travel times and queue lengths
- This phase of calibration characterized by **stable behaviour** of the model :
  - Once network is "behaving", i.e. stable, making significant changes can actually be "hard"
  - This robustness is due to the nature of *equilibrium assignment*

Example: stable conditions (1 of 2)

Network at 9:00

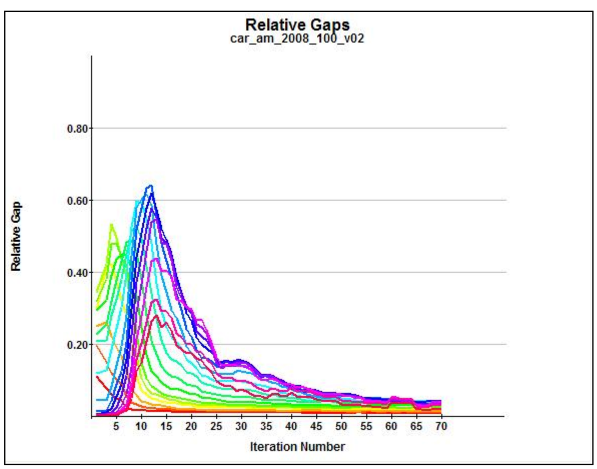




bar width = flow

bar width = density

Example: stable conditions (2 of 2)



Calibration and Data

General remarks

- High coverage of traffic counts is critical to understand the causes behind the outliers:
  - E.g. too little/much traffic on a road because of a coding error on a parallel route: if there are no counts on the parallel route, may be very hard to find the error!
- Good data coverage important for areas that will be modified in future scenarios:
  - Without coverage, do not know if that specific area was properly calibrated in the baseyear
- Tendency to assume inputs are perfect and try to “fix” the model:
  - Always double-check the inputs, and understand the quality/certainty of these data